

## CLAIMS

What is claimed is:

1. A measurement apparatus for determining the angular position  
5 of a first member with respect to a second member about a rotation axis, comprising:

an optical sensor head on the first member, the sensor head comprising a source of a light beam and a plurality of light detecting elements;

10 an offset beam generation element on the second member, the offset beam generation element being operative to receive the light beam from the source and to return an offset light beam to the sensor head, the offset light beam providing a light spot that travels in a generally elliptical path over the light  
15 detecting elements as relative rotation occurs between the first and second members; and

a signal processor operative to process electrical signals produced by the detecting elements to determine the position of the offset beam of light along the elliptical path.

20 2. A measurement apparatus according to claim 1, wherein the light source comprises a solid state source.

25 3. A measurement apparatus according to claim 2, wherein the solid state source comprises a vertical cavity surface emitting laser.

4. A measurement apparatus according to claim 2, wherein the solid state source comprises a light-emitting diode (LED).

30 5. A measurement apparatus according to claim 1, wherein the light detecting elements are disposed to form one or more annuli surrounding the light source.

6. A measurement apparatus according to claim 1, wherein the light detecting elements are arranged in a two-dimensional array.
- 5 7. A measurement apparatus according to claim 1, wherein the beam generation element produces at least one beam of light propagating towards the light detecting elements, the direction of the propagation being at a predetermined offset angle with respect to the rotation axis between the first member and the  
10 second member.
8. A measurement apparatus according to claim 1, wherein the beam generation element produces at least a first beam of light and a second beam of light, the first and second beams propagating  
15 towards the light detecting elements, the direction of propagation of the first beam being at a predetermined angle with respect to the rotation axis and the direction of propagation of the second beam being substantially along the rotation axis.
- 20 9. A measurement apparatus according to claim 1, wherein the beam generation element is reflective.
10. A measurement apparatus according to claim 9, wherein the beam generation element comprises a planar reflective surface  
25 mounted at a predetermined angle with respect to the rotation axis.
11. A measurement apparatus according to claim 9, wherein the beam generation element comprises a reflective diffractive  
30 optical element (DOE), the DOE diffractively producing at least one beam of light propagating towards the light detecting elements, the direction of the propagation being at a

predetermined angle with respect to the rotation axis between the first member and the second member.

12. A measurement apparatus according to claim 11, wherein the DOE comprises a linear diffraction grating.

13. A measurement apparatus according to claim 11, wherein the DOE is a binary diffuser.

14. A measurement apparatus according to claim 1, wherein the beam generation element is transmissive.

15. A measurement apparatus according to claim 14, wherein the beam generation element comprises a prismatic element operative to impart an angular shift to the beam from the source.

16. A measurement apparatus according to claim 14, wherein the beam generation element comprises a transmissive diffractive optical element (DOE), the DOE diffractively producing at least one beam of light propagating towards the light detecting elements, the direction of the propagation being at a predetermined angle with respect to the rotation axis between the first member and the second member.

17. A measurement apparatus according to claim 1, wherein the beam generation element produces at least a first beam of light and a second beam of light, the beams propagating towards the light detecting elements, wherein the first beam of light is adapted to have a predetermined unique characteristic.

18. A measurement apparatus according to claim 17, wherein the signal processor of the apparatus is adapted to identify the

first beam of light based on the predetermined unique characteristic.

19. A measurement apparatus according to claim 17, wherein the predetermined unique characteristic is the polar angular location of the spot generated by the first beam of light.

20. A measurement apparatus according to claim 17, wherein the predetermined unique characteristic is the optical intensity of the first beam of light.

21. A measurement apparatus according to claim 1, further comprising an aperture disposed between the sensor head and the offset beam generation element, the aperture being operative to reduce the size of the light spot on the light detecting elements from the offset light beam.

22. A measurement apparatus according to claim 1, further comprising a lens disposed between the sensor head and the offset beam generation element, the lens being operative to reduce the size of the light spot on the light detecting elements from the offset light beam.

23. A measurement apparatus according to claim 1, wherein the beam generation element produces at least three beams of light propagating towards the light detecting elements, the direction of propagation of each beam being at a respective predetermined angle with respect to the rotation axis.